



Water Chemistry Calculations

Show your work and include units. These are the same calculations treatment plant operators use every day.

Name _____ Date _____

1. River water entering a plant has a pH of 7.8. Calculate the hydrogen ion concentration $[H^+]$.

2. After lime softening, the pH rises to 9.5. How many times lower is $[H^+]$ than in the river water?

3. A student dissolves 250 mg of sodium chloride in 2.0 L of water. What is the concentration in mg/L and in ppm?

4. A lab has a 1,000 mg/L chlorine standard. What volume is needed to make 500 mL of a 2.0 mg/L solution?
($C_1V_1 = C_2V_2$)

5. Water has a chlorine demand of 1.8 mg/L. Operators want a residual of 2.5 mg/L. What dose is needed?

6. A plant treats 100 million gallons per day (MGD). How many pounds of chlorine per day does the dose in question 5 require? ($lb/day = mg/L \times MGD \times 8.34$)

7. River water hardness is 210 mg/L as $CaCO_3$. Convert to grains per gallon (1 gpg = 17.1 mg/L). Using the hardness scale below, is it soft, moderately hard, hard, or very hard?

8. After softening, hardness is 110 mg/L. What percent of the hardness was removed?

Hardness scale (mg/L as $CaCO_3$): 0–60 soft, 61–120 moderately hard, 121–180 hard, over 180 very hard.



The Treatment Train

Match each treatment step with what happens there. Then answer the chemistry questions.

Name _____ Date _____

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|-------------------------------|---|
| 1. _____ Intake and screening | A Heavy floc settles to the bottom of large basins and is removed. |
| 2. _____ Coagulation | B Water passes through layers of sand and anthracite coal that trap remaining particles. |
| 3. _____ Flocculation | C A positively charged chemical neutralizes the negative charges on tiny particles so they can stick together. |
| 4. _____ Sedimentation | D Raising the pH causes calcium and magnesium to precipitate as solids. |
| 5. _____ Lime softening | E Chlorine combined with ammonia forms chloramine, which kills pathogens and stays active in the pipes. |
| 6. _____ Recarbonation | F Slow, gentle mixing grows particles into larger clumps called floc. |
| 7. _____ Filtration | G Carbon dioxide is added to lower the pH so minerals don't coat the filters and pipes. |
| 8. _____ Disinfection | H Bar screens remove sticks, leaves, and fish from river water. |

1. Balance and explain the lime softening reaction: $\text{Ca(OH)}_2 + \text{Ca(HCO}_3)_2 \rightarrow \text{ ___ CaCO}_3 + \text{ ___ H}_2\text{O}$

2. Why would coagulation fail if the particles in the river water were not charged?

3. Chloramine lasts longer in pipes than free chlorine. Why does that matter for a large city system?

4. Pick one step. Design a lab test to measure how well it works. What would you measure, and how?



For teachers

Grade 10 Answer Key

Accept reasonable answers that are supported by evidence.

Water Chemistry Calculations

1. $[H^+] = 10^{-7.8} = 1.58 \times 10^{-8} \text{ M}$
2. $10^{(9.5 - 7.8)} = 10^{1.7} \approx 50 \text{ times lower}$
3. $250 \text{ mg} \div 2.0 \text{ L} = 125 \text{ mg/L} = 125 \text{ ppm}$
4. $V_1 = (2.0 \text{ mg/L} \times 500 \text{ mL}) \div 1,000 \text{ mg/L} = 1.0 \text{ mL}$
5. Dose = demand + residual = $1.8 + 2.5 = 4.3 \text{ mg/L}$
6. $4.3 \times 100 \times 8.34 = 3,586 \text{ lb/day}$
7. $210 \div 17.1 = 12.3 \text{ gpg}$; very hard
8. $(210 - 110) \div 210 \times 100 = 47.6\% \text{ removed}$

The Treatment Train

1. Intake and screening = H, 2. Coagulation = C, 3. Flocculation = F, 4. Sedimentation = A, 5. Lime softening = D, 6. Recarbonation = G, 7. Filtration = B, 8. Disinfection = E

$\text{Ca(OH)}_2 + \text{Ca(HCO}_3)_2 \rightarrow 2 \text{ CaCO}_3 + 2 \text{ H}_2\text{O}$. Hydroxide converts bicarbonate to carbonate; the calcium carbonate is insoluble and settles out.

Uncharged particles would not be attracted to the coagulant, so they would not clump and settle. A longer-lasting residual protects water all the way to the farthest taps.